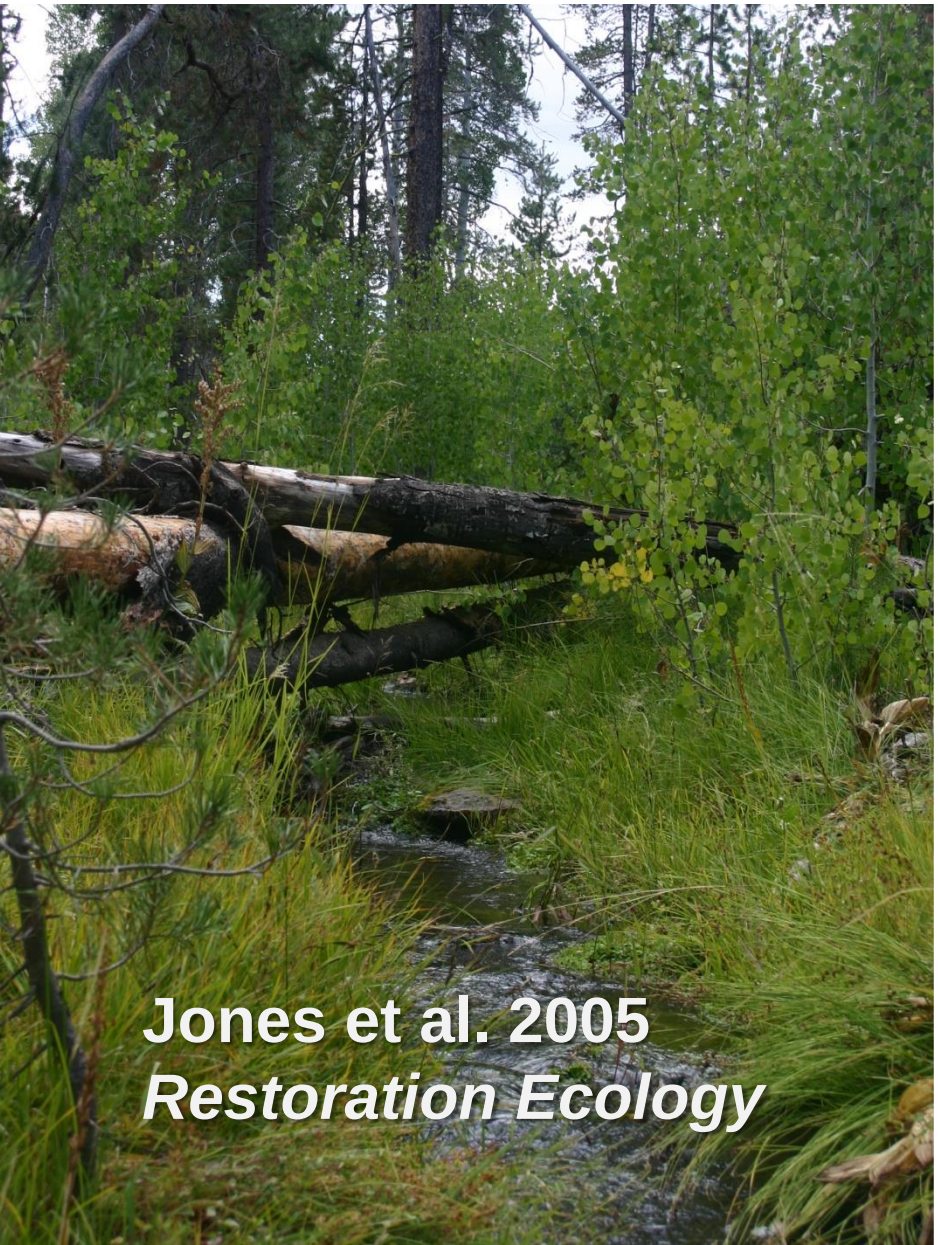
Aquatic Ecosystem Response to Timber Harvesting for the Purpose of Restoring Aspen

Ken Tate, Bobette Jones, and Monika Krupa

Lassen National Forest, Pacific Southwest Region, and UC Davis

- **Many riparian aspen stands encroached by conifers**
- **Conifer removal is an effective release strategy**



Some Concerns

- Reduce stream canopy cover?
- Increase stream temperature?
- Degrade water quality and aquatic habitat?
- Compact soils?

Test Concerns

- Lassen National Forest
- Significant conifer encroachment.
- Active aspen restoration program.
- Collaborative study to evaluate possible aquatic resource impacts.

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RESEARCH ARTICLE

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Abstract

The removal of conifers through commercial timber harvesting has been successful in restoring aspen, however many aspen stands are located near streams, and there are concerns about potential aquatic ecosystem impairment. We examined the effects of management-scale conifer removal from aspen stands located adjacent to streams on water quality, solar radiation, canopy cover, temperature, aquatic macroinvertebrates, and soil moisture. This 8-year study (2003–2010) involved two projects located in Lassen National Forest. The Pine-Bogard Project consisted of three treatments adjacent to Pine and Bogard Creeks: (i) Phase 1 in January 2004, (ii) Phase 2 in August 2005, and (iii) Phase 3 in January 2008. The Bailey Project consisted of one treatment adjacent to Bailey Creek in September 2006. Treatments involved whole tree removal using track-laying harvesters and rubber tire skidders. More than 80% of all samples analyzed for NO_3-N, NH_4-N, and PO_4-P at Pine, Bogard, and Bailey Creeks were below the detection limit, with the exception of naturally elevated PO_4-P in Bogard Creek. All nutrient concentrations (NO_3-N, NH_4-N, PO_4-P, K, and SO_4-S) showed little variation within streams and across years. Turbidity and TSS exhibited annual variation, but there was no significant

Subject Areas

Conifers
Ecosystems
Forests
Pines
Solar radiation
Solid-phase extraction
Timber
Turbidity

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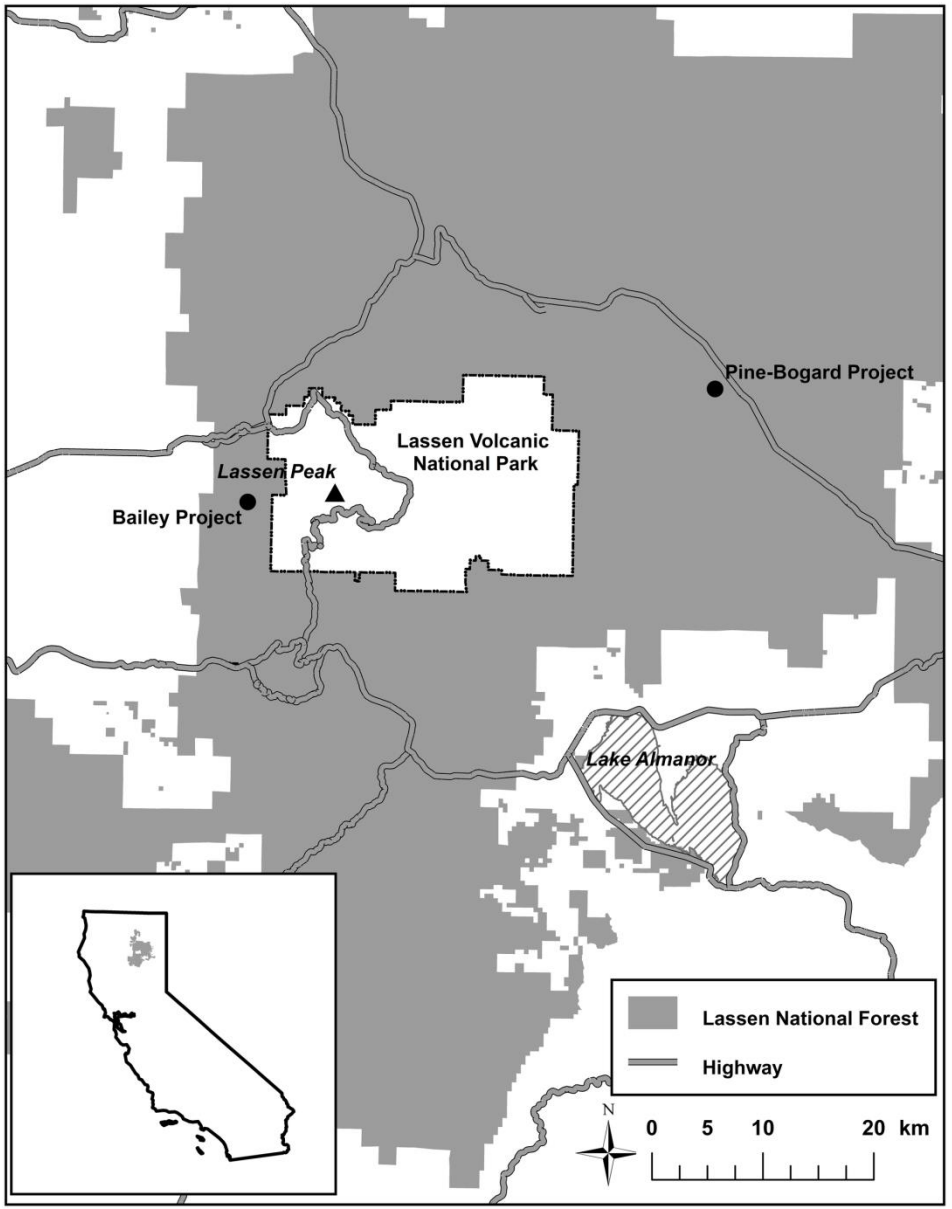
Study Sites


Pine-Bogard Project
Lassen Volcanic
National Park
Lassen Peak
Bailey Project
Lake Almanor
Lassen National Forest
Highway
N
0 5 10 20 km

2 Sites, 4 Treatments (Cuttings)

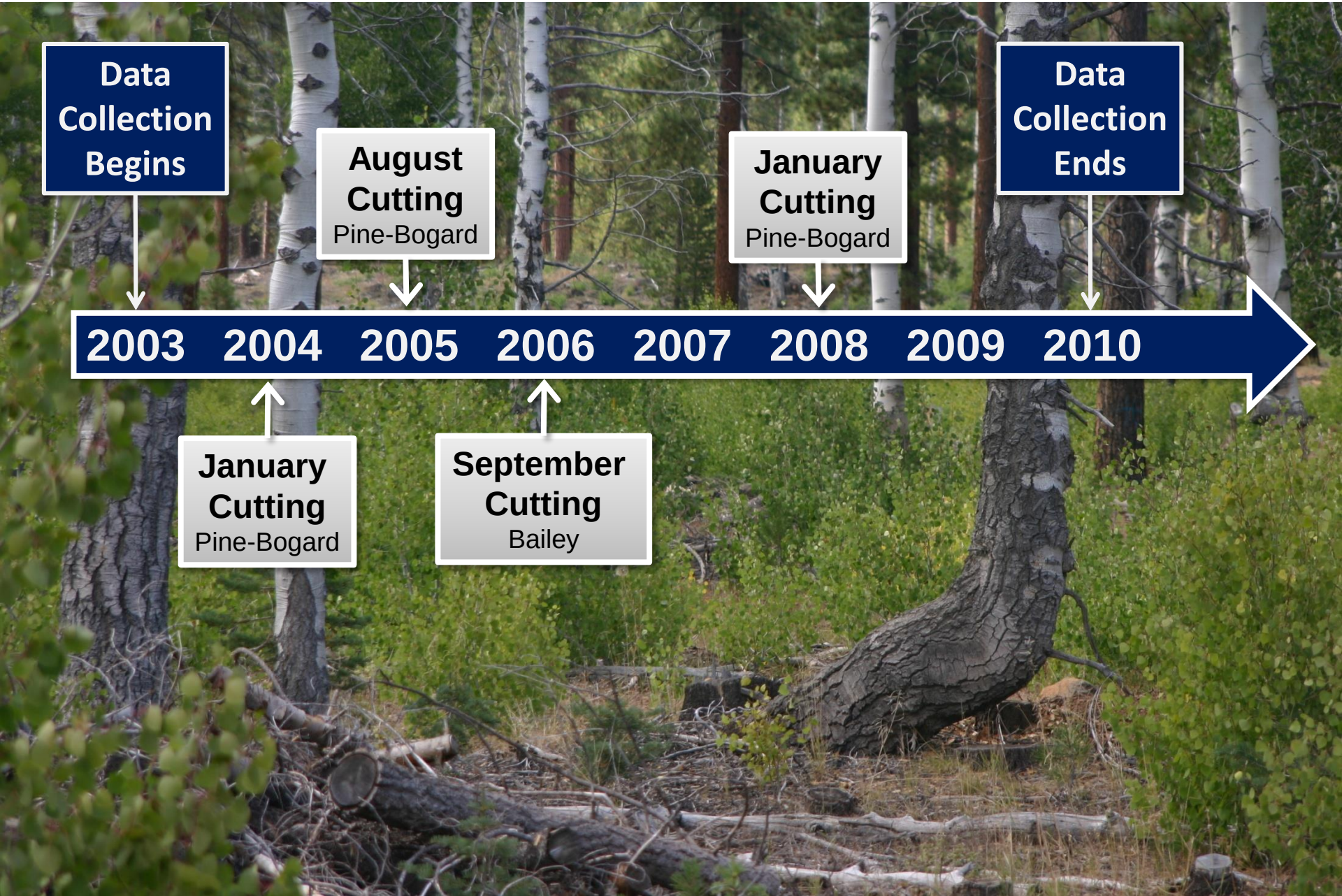
Pine-Bogard Creeks

Jan 2004 – Phase 1
Aug 2005 – Phase 2
Jan 2008 – Phase 3

Bailey Creek

Sep 2006

Study Timeline

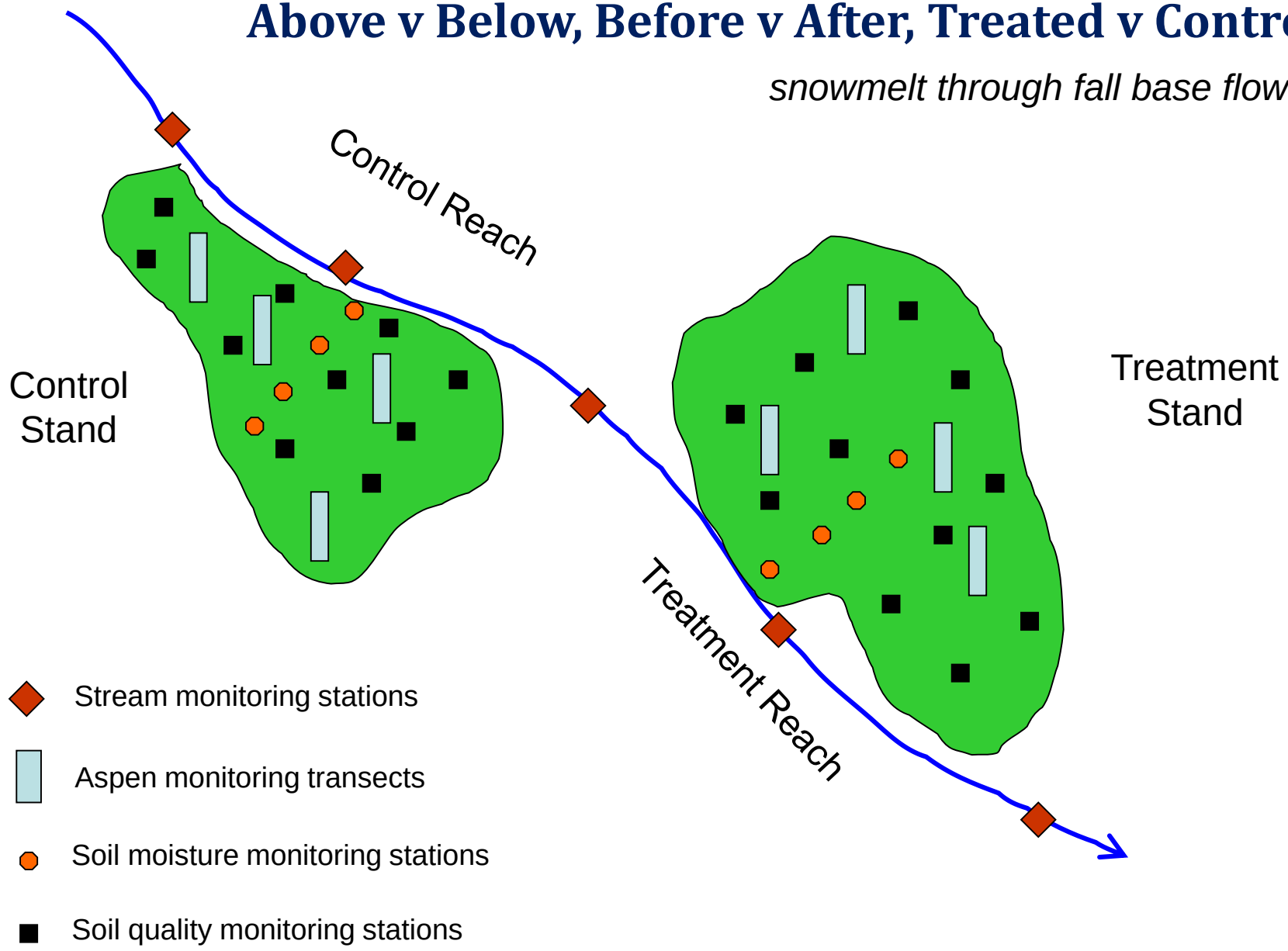


Response Metrics

- Water Quality
- Stream Canopy Cover and Solar Radiation
- Stream Temperature
- Aquatic Macroinvertebrates
- Soil Bulk Density
- Soil Moisture

Above v Below, Before v After, Treated v Control

snowmelt through fall base flows

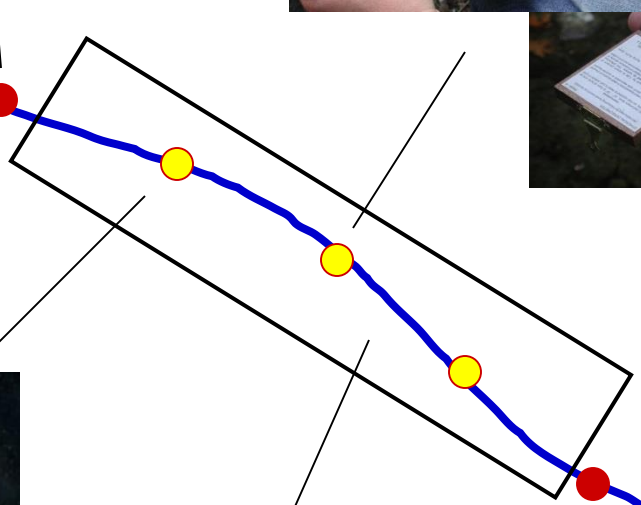


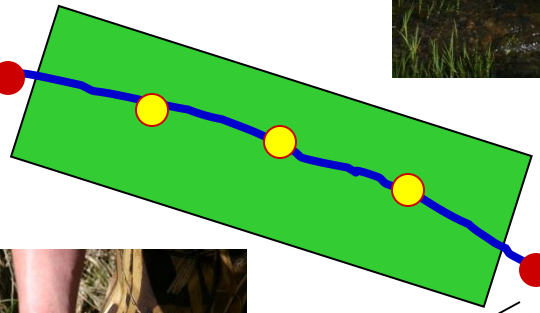
Continuous

Annual

2x month

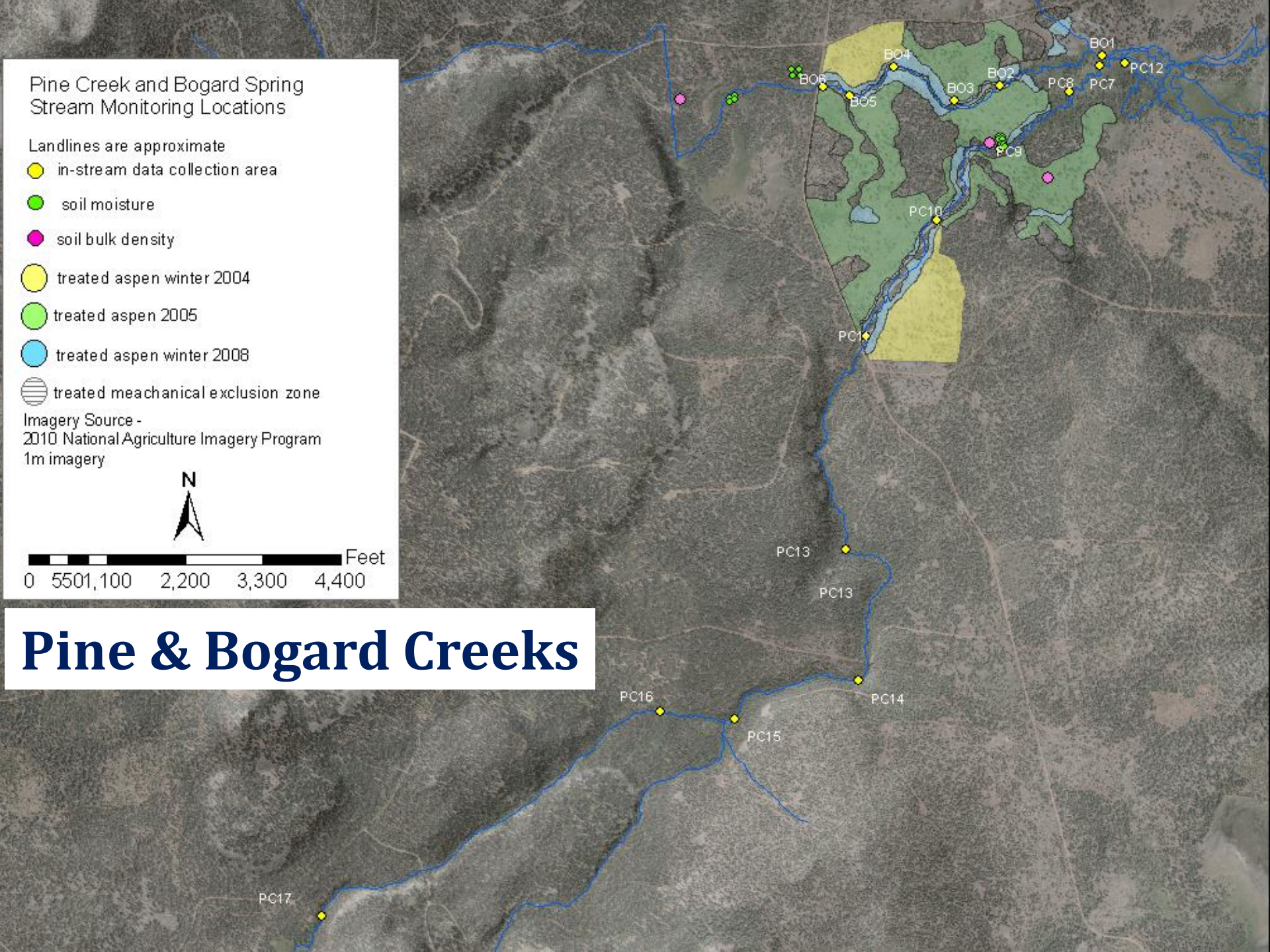
Annual





Annual

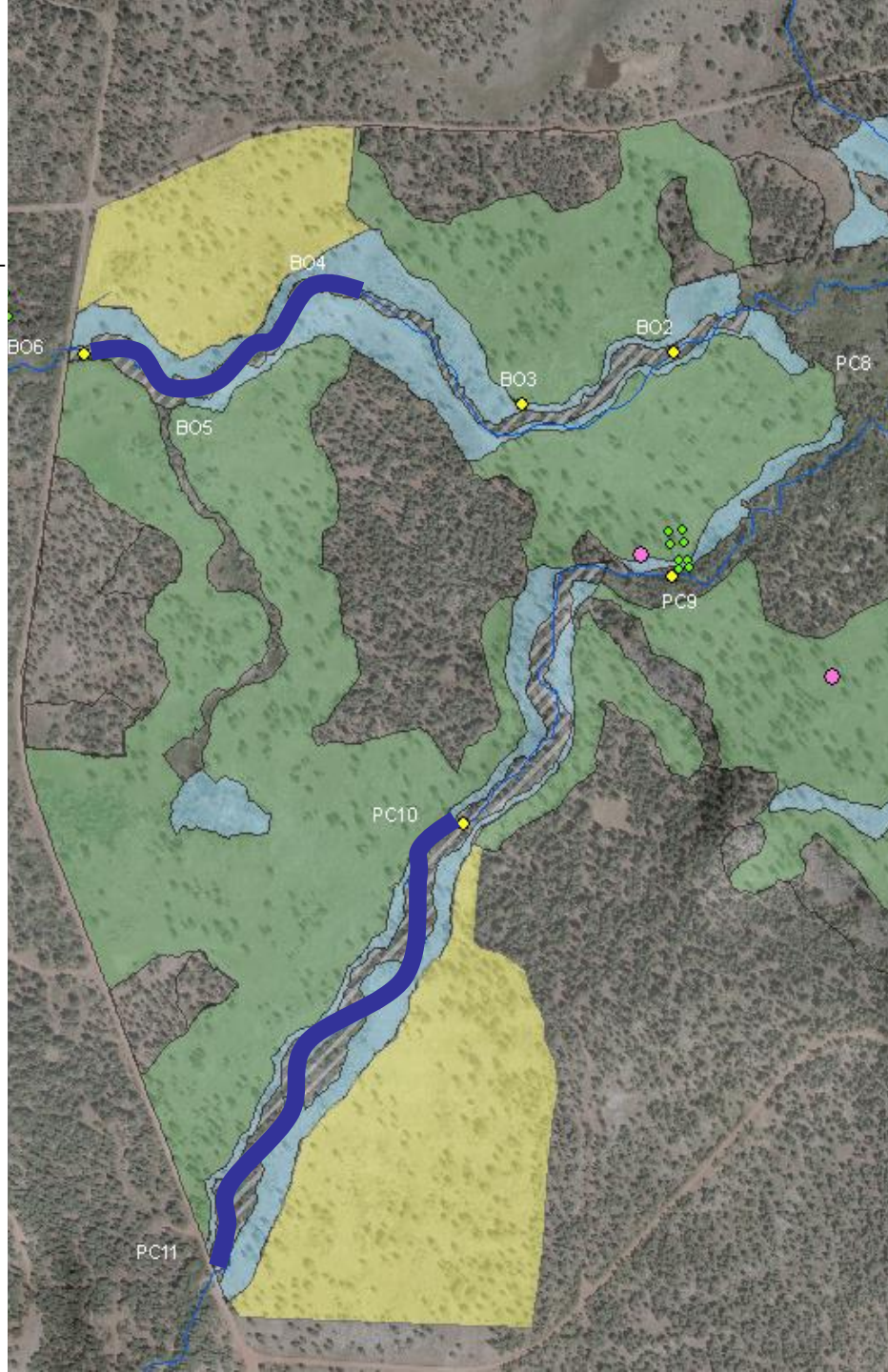
2x month



Pine & Bogard Creeks

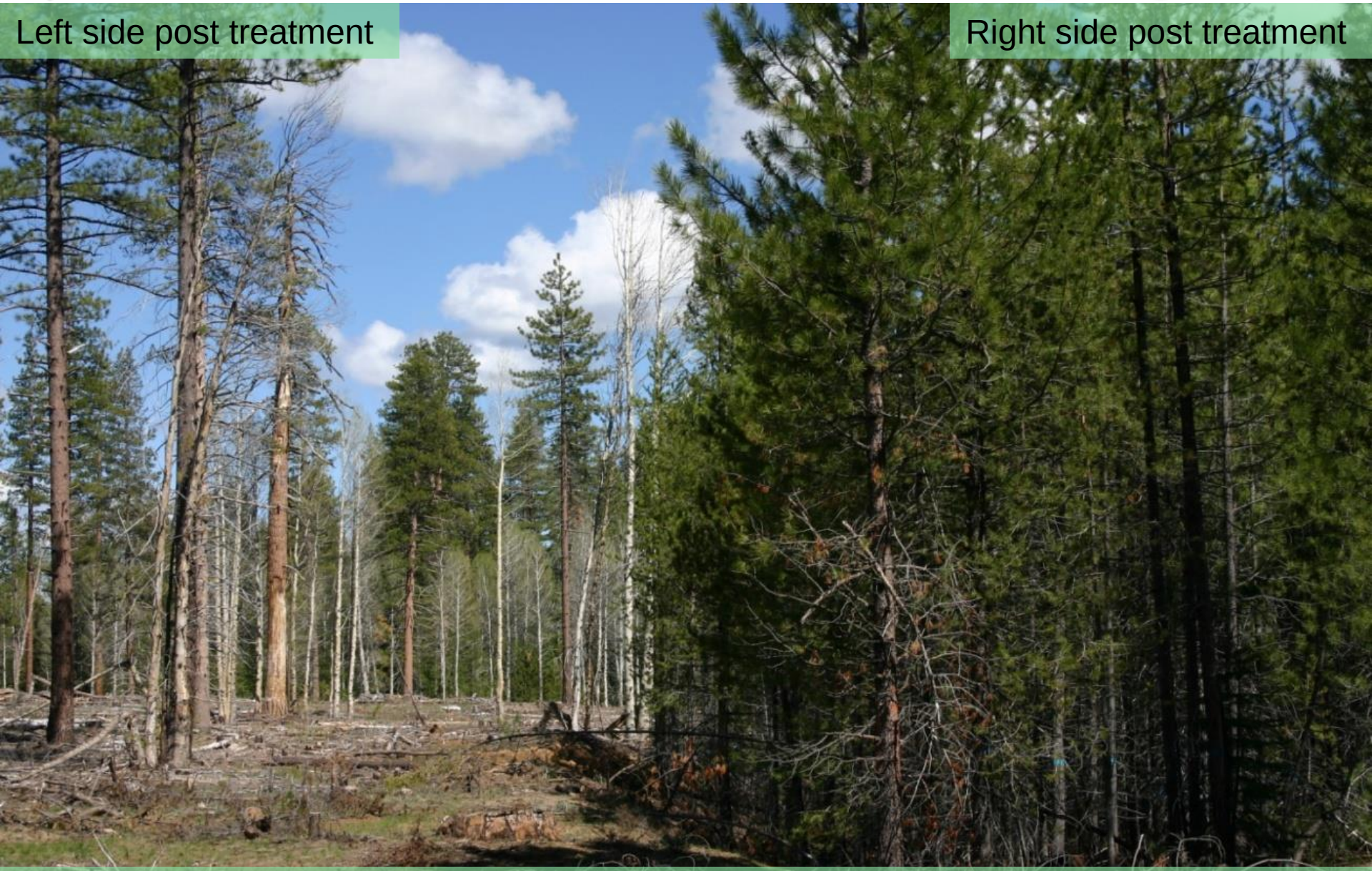
Jan 2004 Treatment (yellow)

- ~24 ha, Pine Cr. 720 m, Bogard Cr. 430 m.
- Over snow, min 60 cm snow or 10 cm frozen ground
- Whole tree (< 75 cm DBH)
- < 25 m from stream hand felled and end-lined out.
- > 25 m from stream used track-laying harvester, skidders.



Jan 2004 Treatment

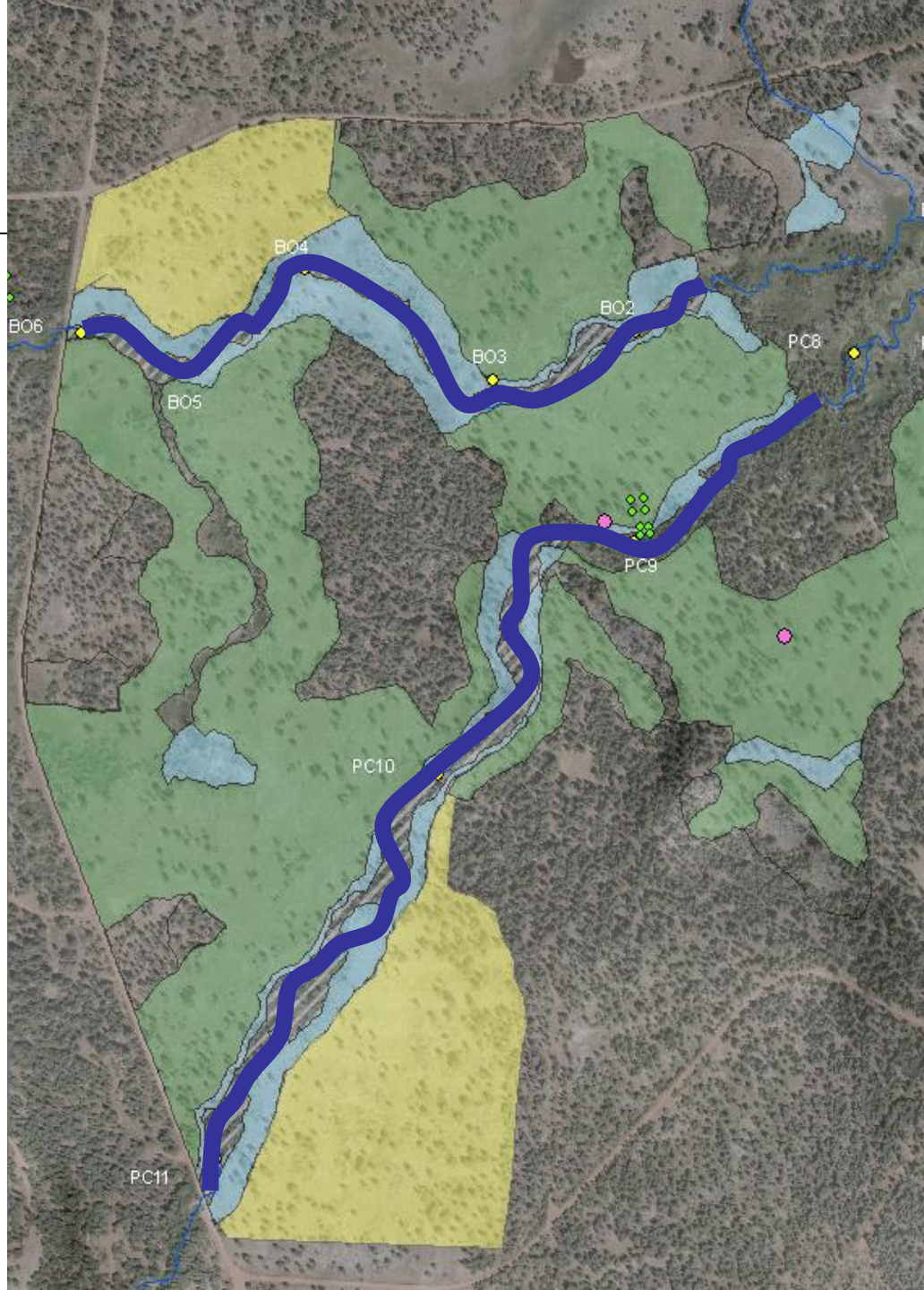
Jan 2004 Treatment (photo taken spring 2004)



Bogard Creek- located 100 ft right of treatment boundary

Aug 2005 Treatment (green)

- 80 ha, Pine Cr. 1,800 m, Bogard Cr. 1,090 m.
- Late harvest – dry soils, further reduce slash
- Whole tree (< 75 cm DBH)
- Variable min distance from stream based on slope, ground cover – 4 to 40 m.
- Track-laying harvester, skidders.

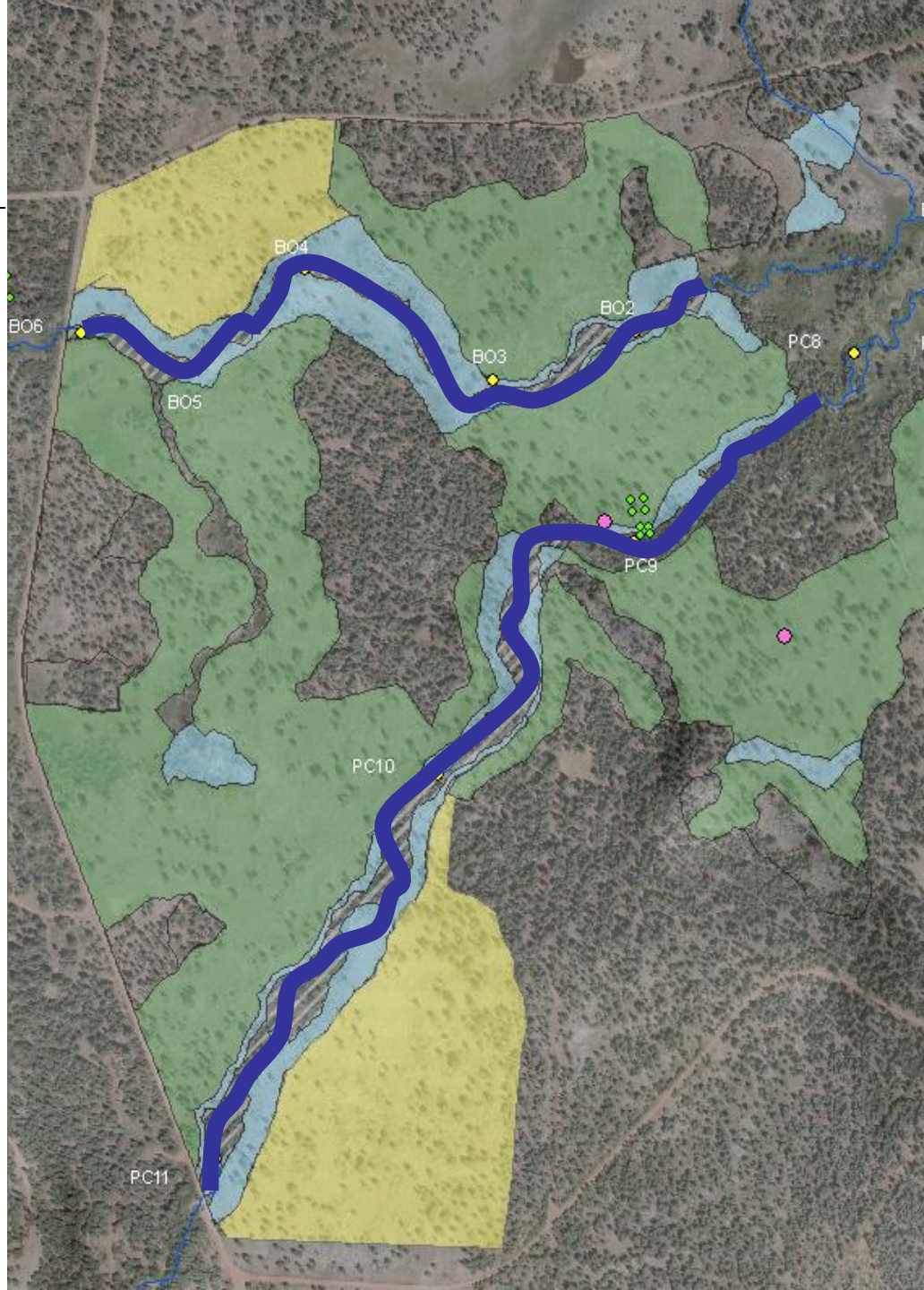


Aug 2005 Treatment

Jan 2008 Treatment

(blue)

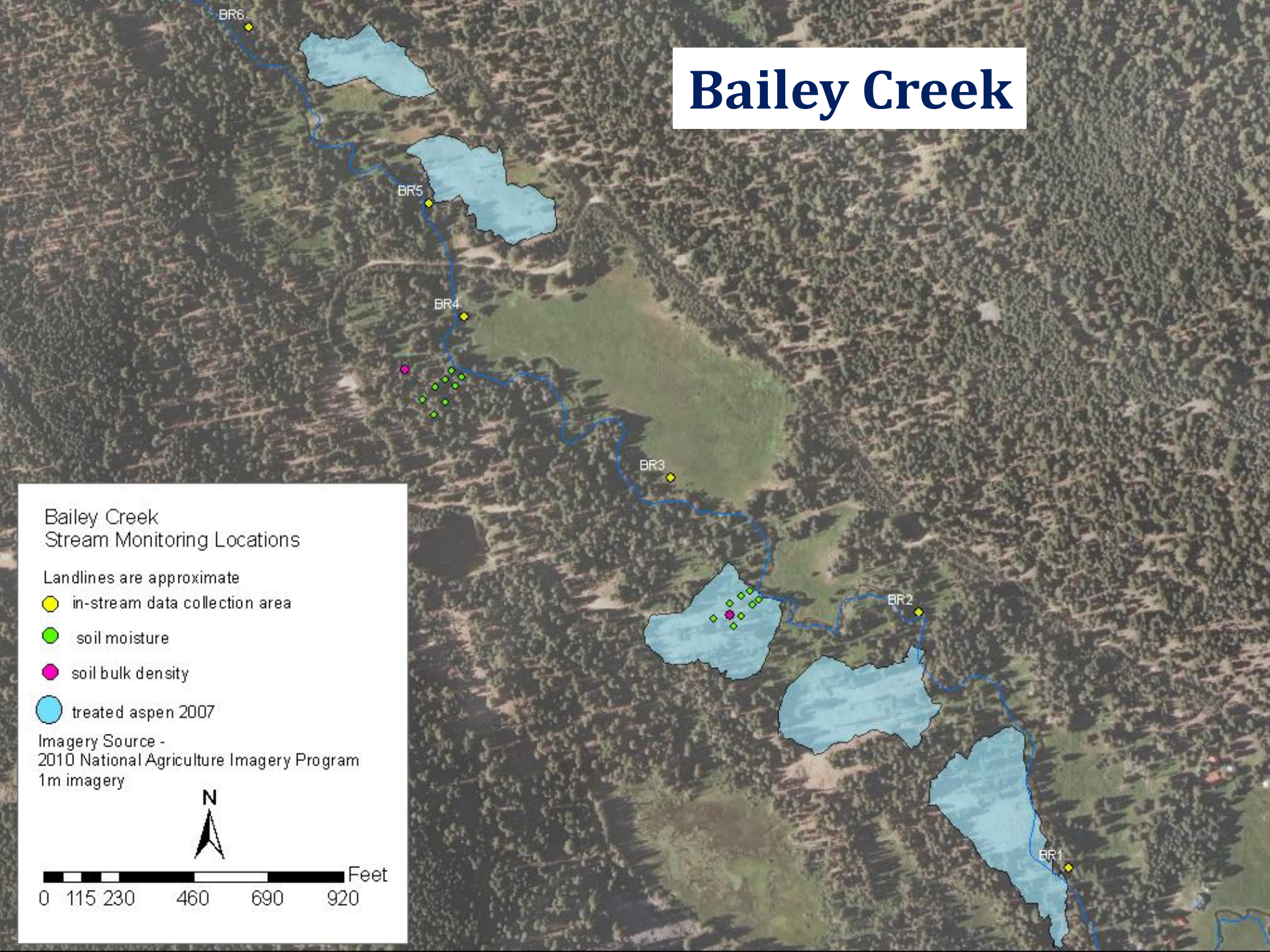
- 13 ha, Pine Cr. 1,800 m, Bogard Cr. 1,090 m.
- Over snow, whole tree (<75 cm DBH)
- No equipment zone from waters edge to edge continuous vegetation.
- Conifers in no equipment zone and not contributing to streambank stability were felled and lifted out.



Snow depth during Jan 2008 treatment

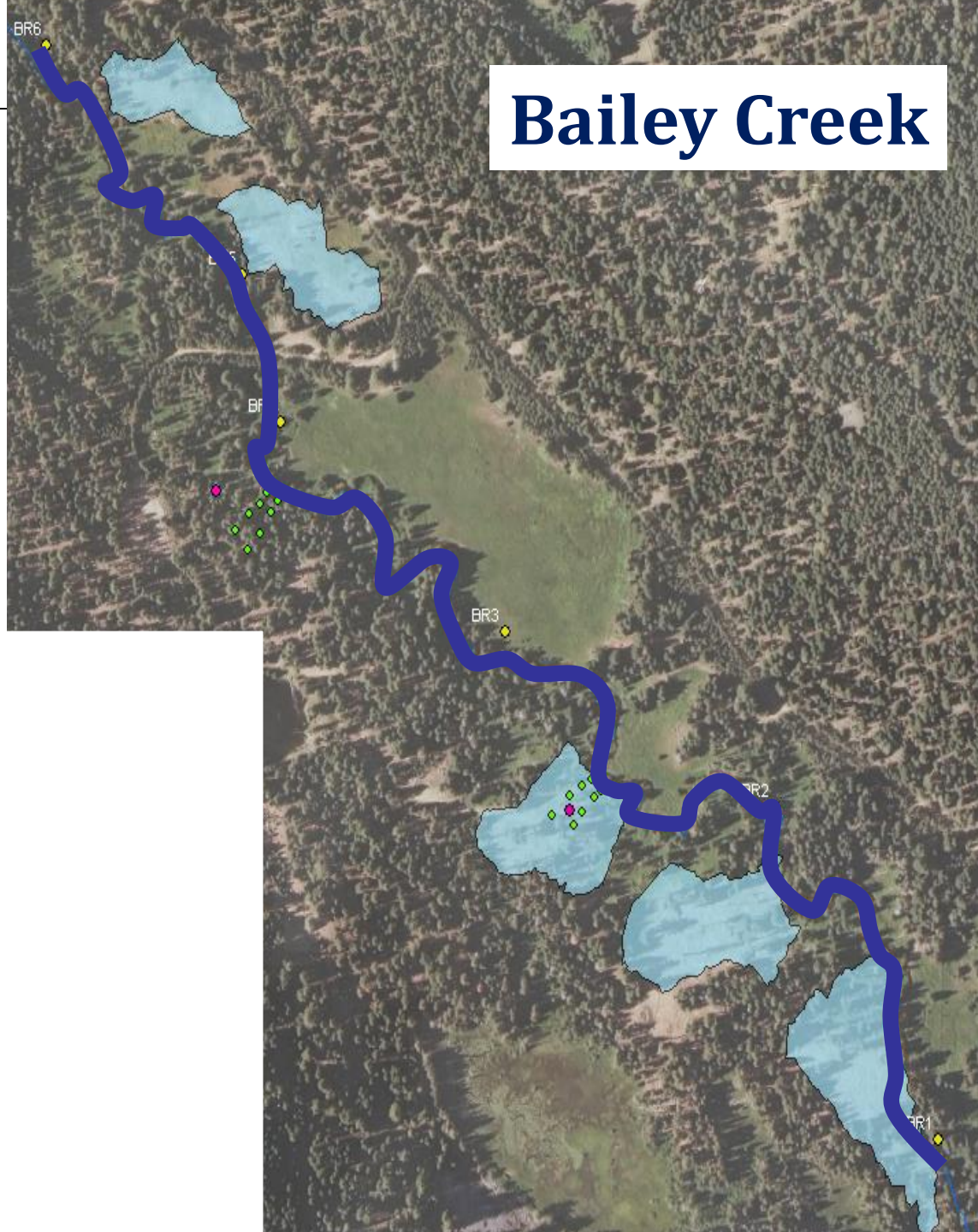
Bogard Creek following Jan 2008 treatment
(photo taken early Spring 2008)

Bailey Creek



Sep 2006 Treatment

- ~4.5 ha, Bailey Creek 560 m.
- Late harvest – dry soils
- Whole tree (10 – 75 cm DBH).
- Variable distance from stream based on slope, ground cover – 1.5 to 90 m.
- Track-laying harvester, skidders.
- <10 cm DBH were cut, pilled, and burned outside aspen clone root zone.



Stream water quality changes between up and down stream sites after conifer removal.

N, P, turbidity, suspended sediments, DO, pH, etc.

Bogard Creek

Conifer Removal – Aspen Stand

No water quality changes were detected

- Means (mg/L) for all samples collected across treatment stream sample stations.
- NO_3-N background is 0.005 to 0.04, eutrophication concerns if >0.3 mg/L.
- PO_4-P eutrophication concerns if >0.05 mg/L.
- Overall extremely clean water.

Creek	No. Samples Collected	Nutrient	No. Samples < DL [a]	% Samples < DL [a]	Mean of all Samples	Mean of all Samples > DL [a]
Pine	758	NO_3-N	636	84	0.007	0.03
		NH_4-N	753	99	0.027	0.26
		PO_4-P	651	86	0.01	0.04
Bogard	430	NO_3-N	348	81	0.008	0.03
		NH_4-N	432	99	0.026	0.47
		PO_4-P	63	15	0.04	0.04
Bailey	315	NO_3-N	272	86	0.005	0.02
		NH_4-N	293	93	0.030	0.09
		PO_4-P	311	99	0.005	0.04

[a] DL = Detection Limit

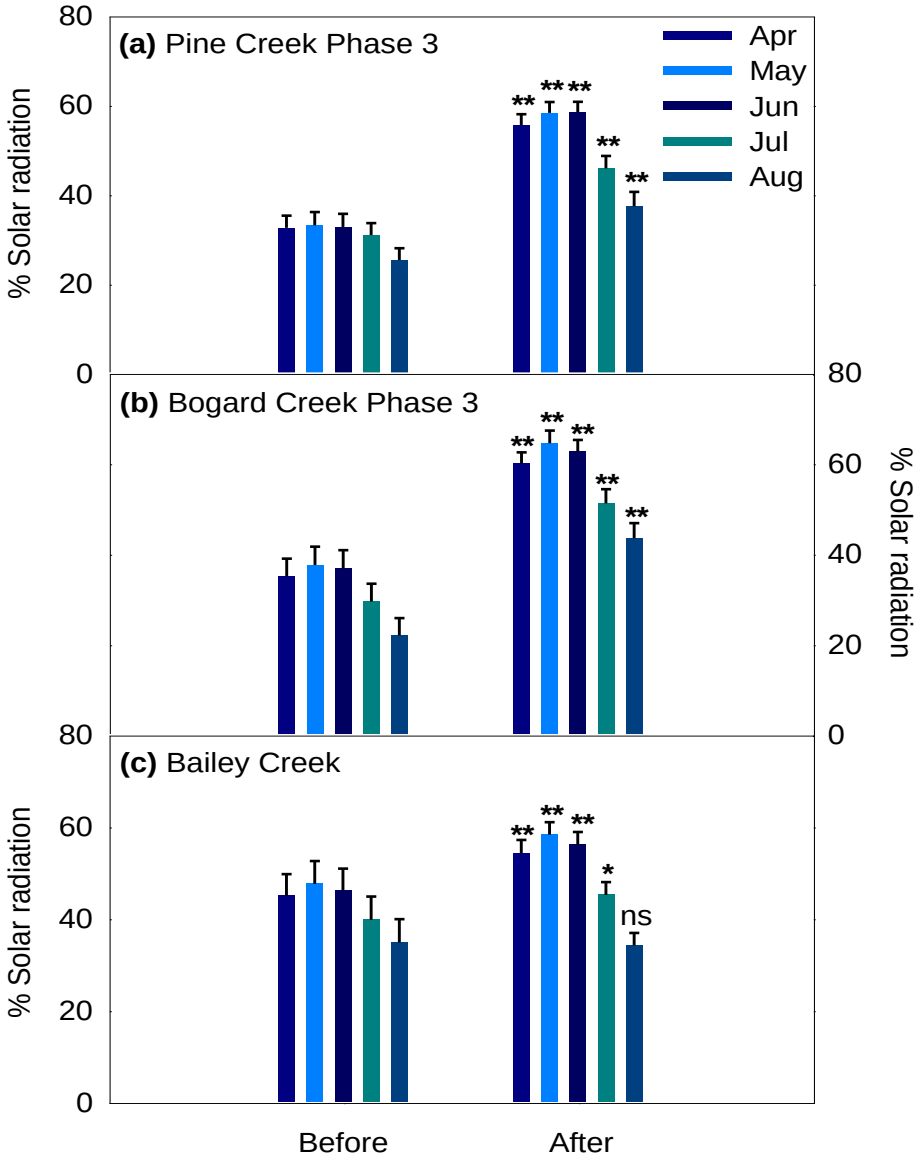
Stream canopy cover and solar input changes in treatment reaches following conifer removal.

Bogard Creek

Conifer Removal – Aspen Stand

Stream Solar Radiation Input

- Canopy cover significantly decreased in response to Pine-Bogard Jan 2008 and Bailey treatments.
- Solar radiation significantly increased in response to Pine-Bogard Jan 2008 and Bailey treatments.
- There was no response of canopy cover or solar radiation to other treatments.



* significantly different, P < 0.05
** significantly different, P < 0.005

Stream temperature changes between up and down stream sites after conifer removal.

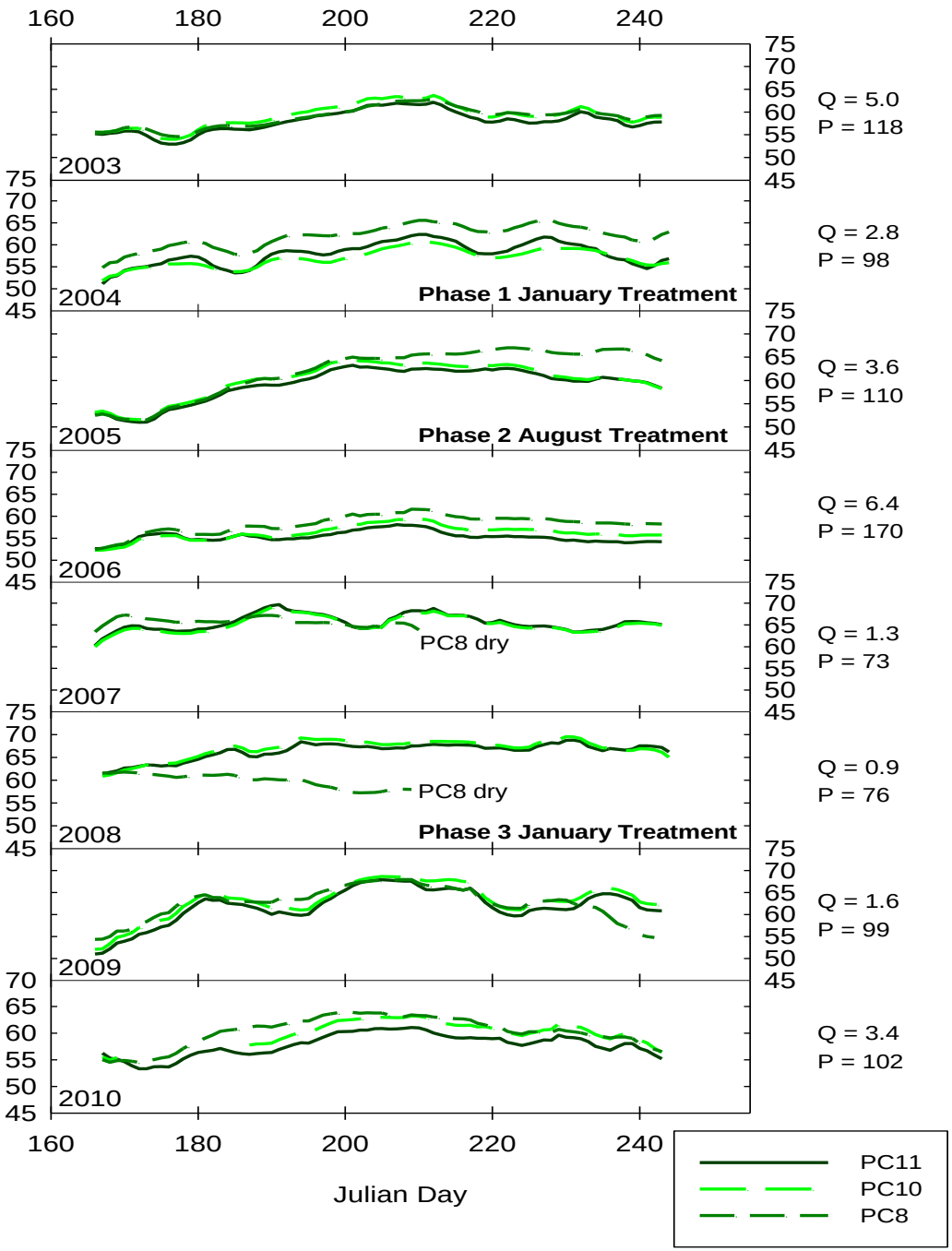
Bogard Creek

Conifer Removal – Aspen Stand

Stream Temperature

Pine Creek seven day running average daily maximum water temperature

- These was no increase (or change) in rate of water warming through treatment stream reaches.
- Annual stream temperature primarily driven by annual fluctuations in discharge, with the warmest stream temperature occurring during the lowest flow years.

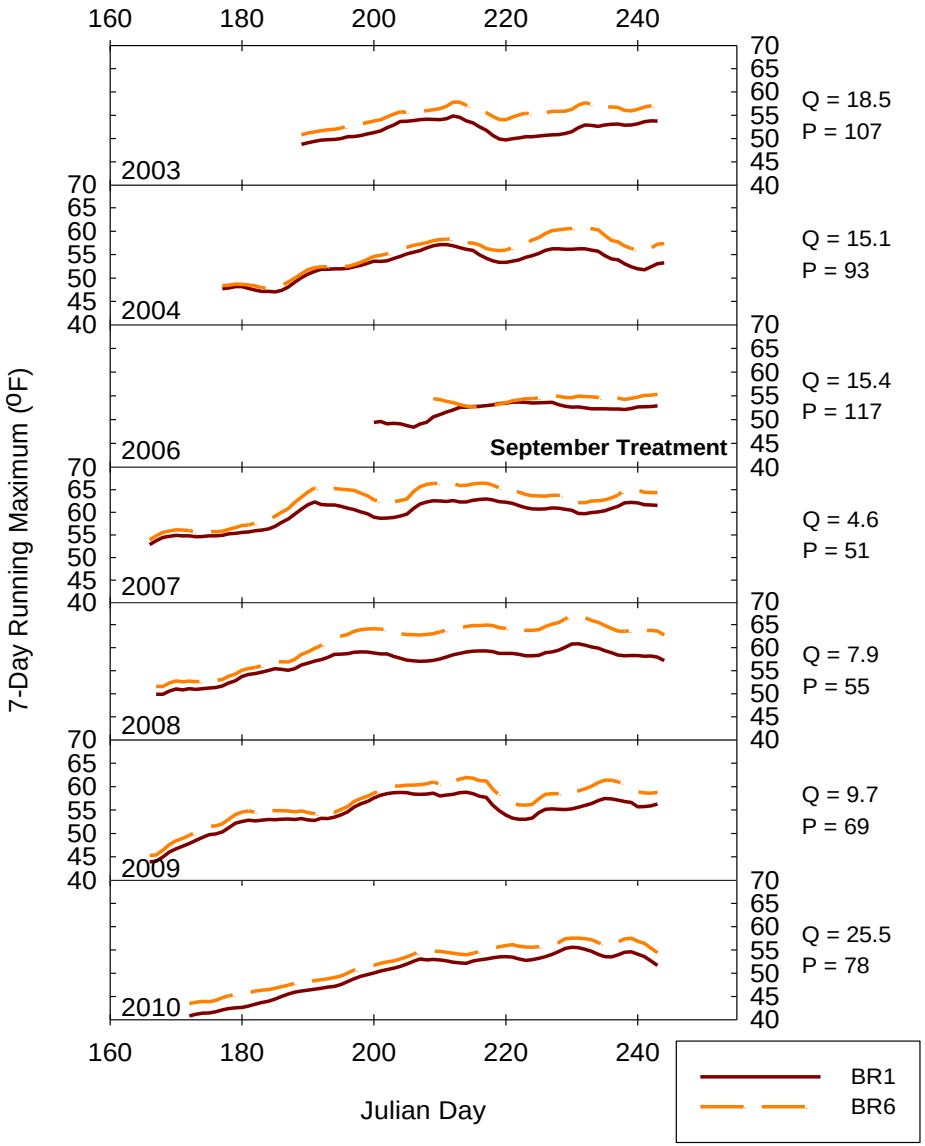


Stream Temperature

There are several possible reasons for the lack of response:

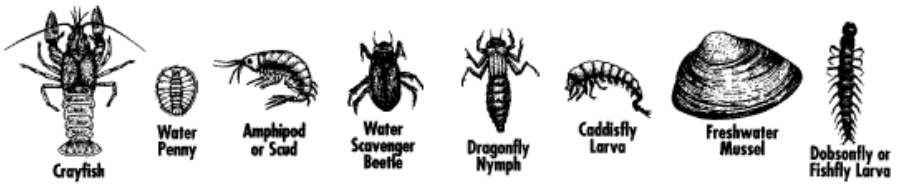
- The decrease in canopy cover was small Pine and Bailey Creeks (9% and 7% decrease, respectively).
- Still a substantial canopy cover at Pine Creek (55%), Bogard Creek (39%), and Bailey Creek (45%) to continue to moderate stream temperature.
- At Bailey Creek, stream temperature change is likely buffered by the relatively high, cool flows that characterize the creek all season-long.
- It is likely that the affected reach lengths at each creek were not long enough to allow for a water residence time that could result in increased temperatures.

Bailey Creek seven day running average daily maximum water temperature



Aquatic Macroinvertebrates

		2003		2010	
		Above	Below	Above	Below
Pine	Richness	17	16	26	21
	Diversity	2.3	2.4	1.8	1.8
	% Tolerant	0.2	0	0.1	0
Bogard	Richness	17	12	22	23
	Diversity	2.8	2.0	2.7	2.3
	% Tolerant	0	0	0	0
Bailey	Richness	11	13	21	17
	Diversity	2.0	2.3	2.8	2.9
	% Tolerant	0	0	0	0



Soil Compaction - Bulk Density

Test for change before and after conifer removal

Pine Creek

Permanent sample areas.

Treatment and reference.

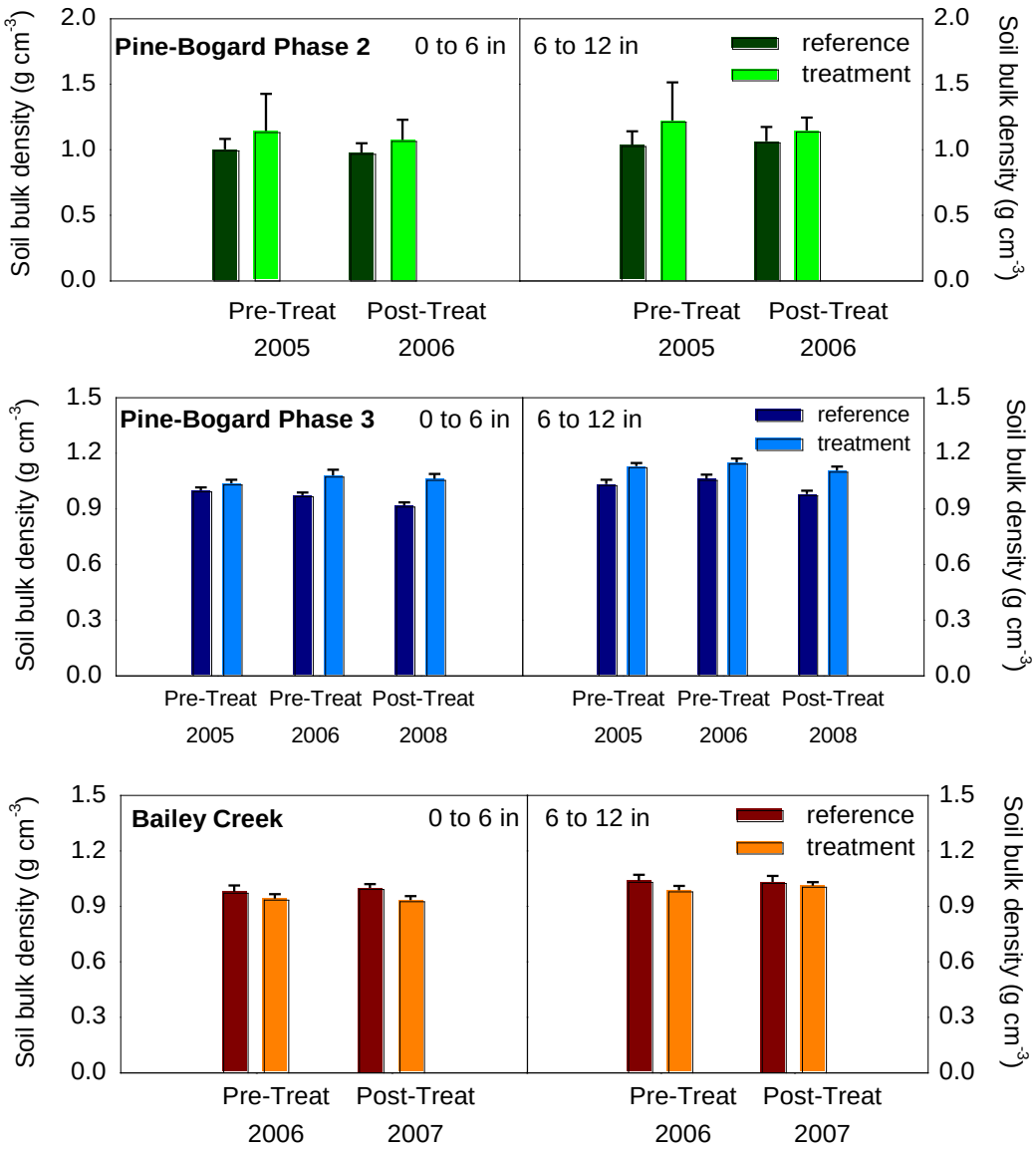
0 to 6 in, and 6 to 12 in depth.

Conifer Removal – Aspen Stand

Soil Bulk Density

- There were no significant difference between treatment and reference soil bulk densities at the 0-6 or 6-12 inch depths for any treatments at Pine, Bogard, or Bailey Creeks.
- Soil bulk density monitoring stations were located in harvest unit areas outside of defined skid trails and log landings.

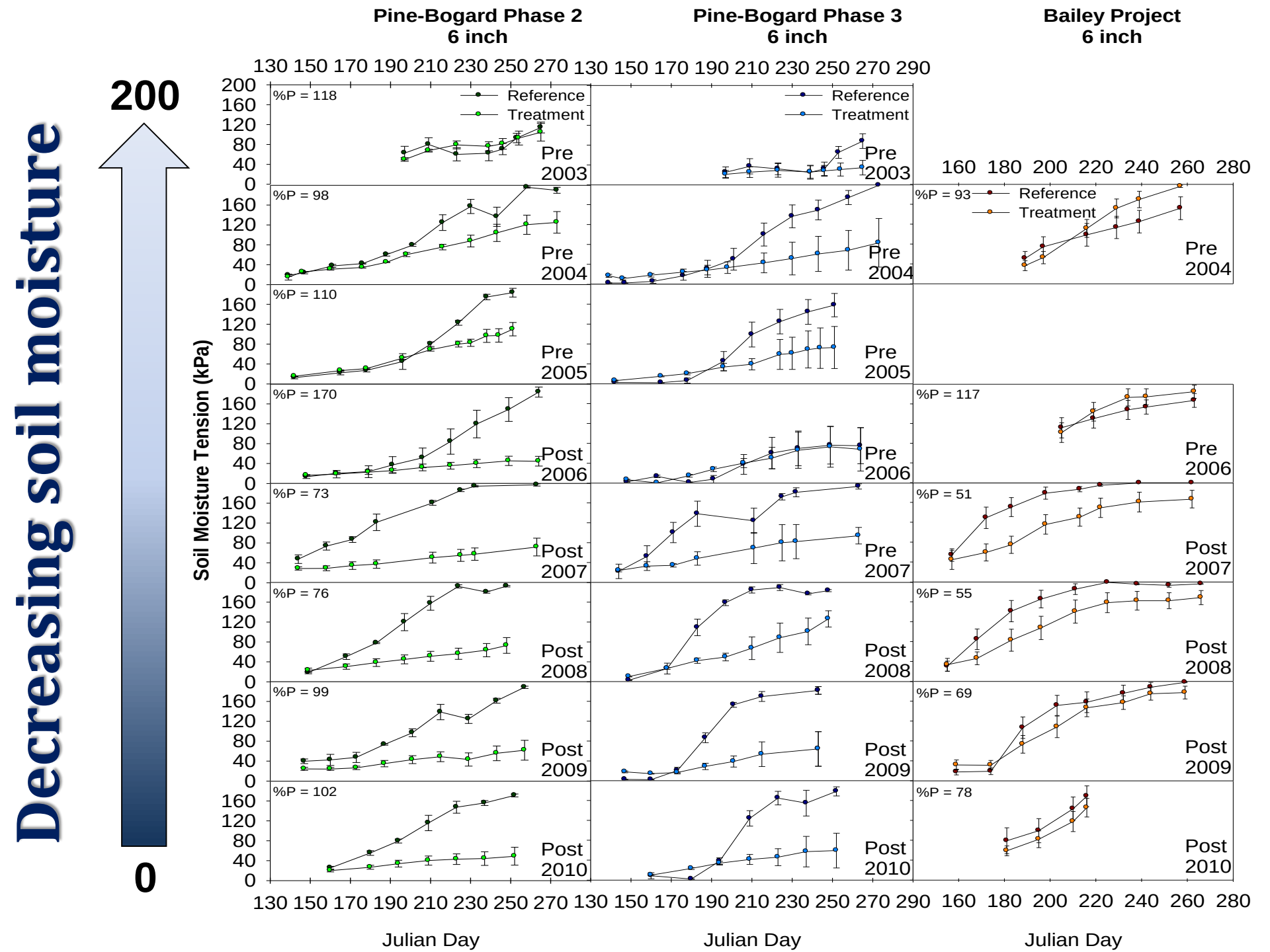
Mean and standard error of soil bulk density for treatment and reference aspen stands before and after treatments



Soil Moisture

- Post treatment soil moisture at 6 and 18 inches increased significantly relative to reference soil moisture in response to Pine, Bogard, and Bailey Creek treatments ($P < 0.001$).

- Increased soil moisture within treatment units was likely from reduced transpiration.


Pine-Bogard Phase 2
6 inch
Pine-Bogard Phase 3
6 inch
Bailey Project
6 inch
Decreasing soil moisture
200
0
Soil Moisture Tension (kPa)
Reference
Treatment
%P = 118
%P = 98
%P = 110
%P = 170
%P = 73
%P = 76
%P = 99
%P = 102
%P = 93
%P = 117
%P = 51
%P = 55
%P = 69
%P = 78
Pre 2003
Pre 2004
Pre 2005
Post 2006
Pre 2006
Post 2007
Pre 2007
Post 2008
Post 2009
Post 2010
Julian Day

Conifer removal to restore riparian aspen stands:

i. had no effect on water quality or aquatic macroinvertebrates

ii. had no effect on soil bulk density but did cause a significant increase in soil moisture

iii. decreased canopy cover and increased solar radiation following the Bailey Project and following Phase 3 of the Pine-Bogard Project, but did not influence stream temperature.

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